Space Weather Technical Forecast

Issued on Monday, 07 February 2022 at 00:52 Local

This technical forecast provides a four-day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales

Space Weather Forecast Headline: Partial halo CME observed from near centre-disc filament eruption. G1 Likely midweek, Chance of continuation into Thursday.

Analysis of Space Weather Activity over past 24 hours

Solar Activity: Solar activity was Low through the UTC day of Sunday 06 February, with occasional C-class X-ray flares observed at GOES 16. The largest of these events was a long-period C3.1 X-ray flare, peaking at 06/1341UTC. This was associated with a near-centre disc filament eruption that was visible in many EUV wavelengths, with this emanating from the immediate east of sunspot region 2939.

There are currently five sunspot regions on the disc, including the aforementioned 2939, with this group finishing the 24 hours as a Cho/Beta, with slight growth in its trailing spots evident. The two most noteworthy groups in terms of magnetic complexity were both assessed as Eai/Beta, with one in the northern hemisphere near the meridian (AR2940), and one in the northeast, AR2941. Of these, the former showed slight proliferation in its intermediate portion, while the latter showed a consolidating trend, with neither producing significant flares. The remaining two sunspot groups both lay near the western solar horizon, being AR2942, a Bxo/Beta, and a now difficult to distinguish Dri/Beta, 2938.

Early in the UTC day a Coronal Mass Ejection (CME) was observed leaving the southwestern limb, although this is unlikely to affect Earth. Of much greater significance is the aforementioned (at least) partial halo CME generated from the filament eruption (its associated flare peaking 06/1341UTC).

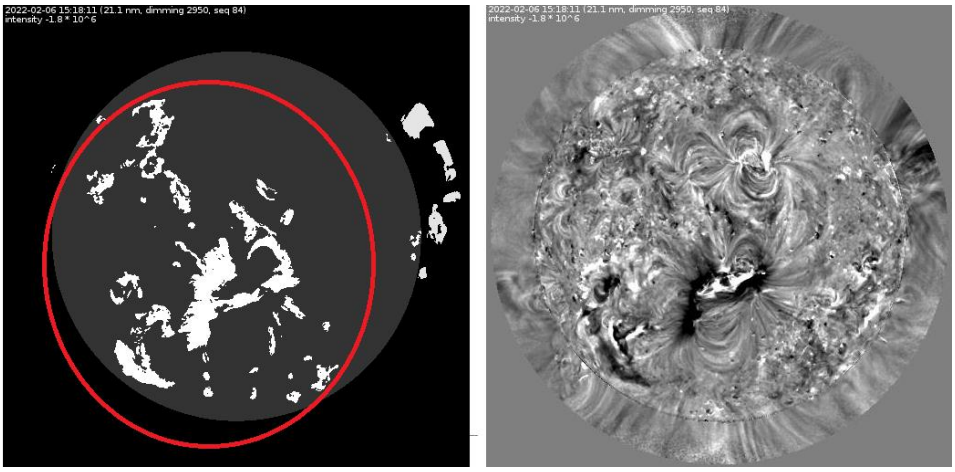


Figure 0a: SIDC ROB time-integrated visualisation of the dimming associated with the centre-disc filament eruption, peaking 06/1341UTC. The left-hand image shows the unusually wide spread of the dimming ringed in red (for being face-on), while the origin can be more clearly seen in the right hand image (AIA 211) in the lower centre of the disc.

Issued by Met Office Space Weather Advisor, Tel: +44 (0) 330 135 4254 Email: moswoc@metoffice.gov.uk

© Crown Copyright 2022. All Rights Reserved.

The emission itself appeared helicoidal and well-scattered given the face-on viewing angle, being directed mainly along and below the ecliptic plane, perhaps centred very slightly east of Earth. With reference made to STEREO A COR2 and Lasco imagery, this feature has been modelled as three separate CMEs to provide a best match - with two of these fronts mainly angled below the ecliptic, but the third (the innermost and slowest) bearing a likely Earth-bound component. Discussion as to the effects of this emission appears in the Geomagnetic Storms section of this guidance document.

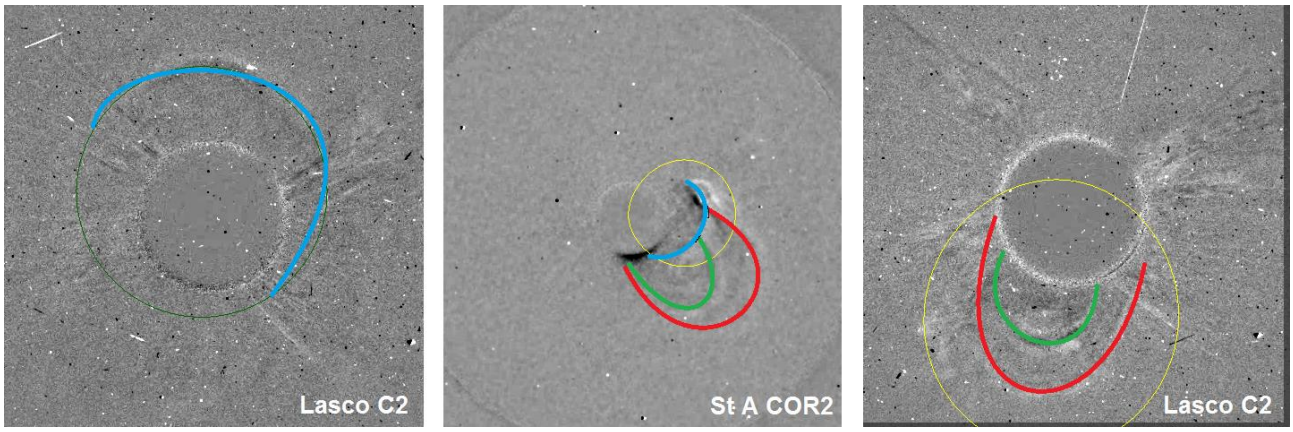


Figure 0b: p.m. 06 February coronagraph imagery of the centre-disc filament, outlining the three main fronts visible from various perspectives. The slowest but potentially most significant (for being potentially the most directly-Earthbound) is shown in blue.

Solar Wind / Geomagnetic Activity: The solar wind, as observed at L1 by DSCOVR, was characteristic of connection to a negative polarity high speed stream, probably that from the now no longer distinguishable CH49, but perhaps cleanly segueing into CH51, with both being of negative polarity and therefore likely indistinguishable. The phi angle was accordingly towards the sun (negative) for the vast majority of the reporting period.

The solar wind speed was elevated in the upper 500s of km/s at peak, with a gradual downward trend becoming apparent later in the 24 hours to approach 500km/s. The solar wind density was roughly level near 10ppcc throughout, while the IMF was also near-level at a peak of 6nT, with the north-south component ranging between +/-5nT.

The net effect of the above solar wind measures was for Quiet to Active Kp, with a provisional Kp 4- recorded in the 00-03UTC interval.

Energetic Particles / Solar Radiation: The high energy proton flux (greater than 10 MeV) measured at GOES 16 was at background levels.

The high energy electron flux has been mainly at High levels, peaking at 4440pfu at 06/1505UTC. Electron fluence values showed a sustained rise through Active fluence, finishing the period with an observed value of 1.84e8 integrated pfu at 07/0000UTC.

Four-Day Space Weather Forecast Summary

Solar Activity: Solar activity is expected to be Low in the period. No significant regions appear to lie over the eastern horizon, while up to two current front-sided regions may leave into the new working week. This leaves the three most potent groups present throughout the four days on the Earth-facing side, giving only a very modest decline in X-ray flare risk.

Solar Wind / Geomagnetic Activity: The current fast solar wind regime is likely to be the peak persistent feature in the four-day period, now expected to gradually wane through to midweek

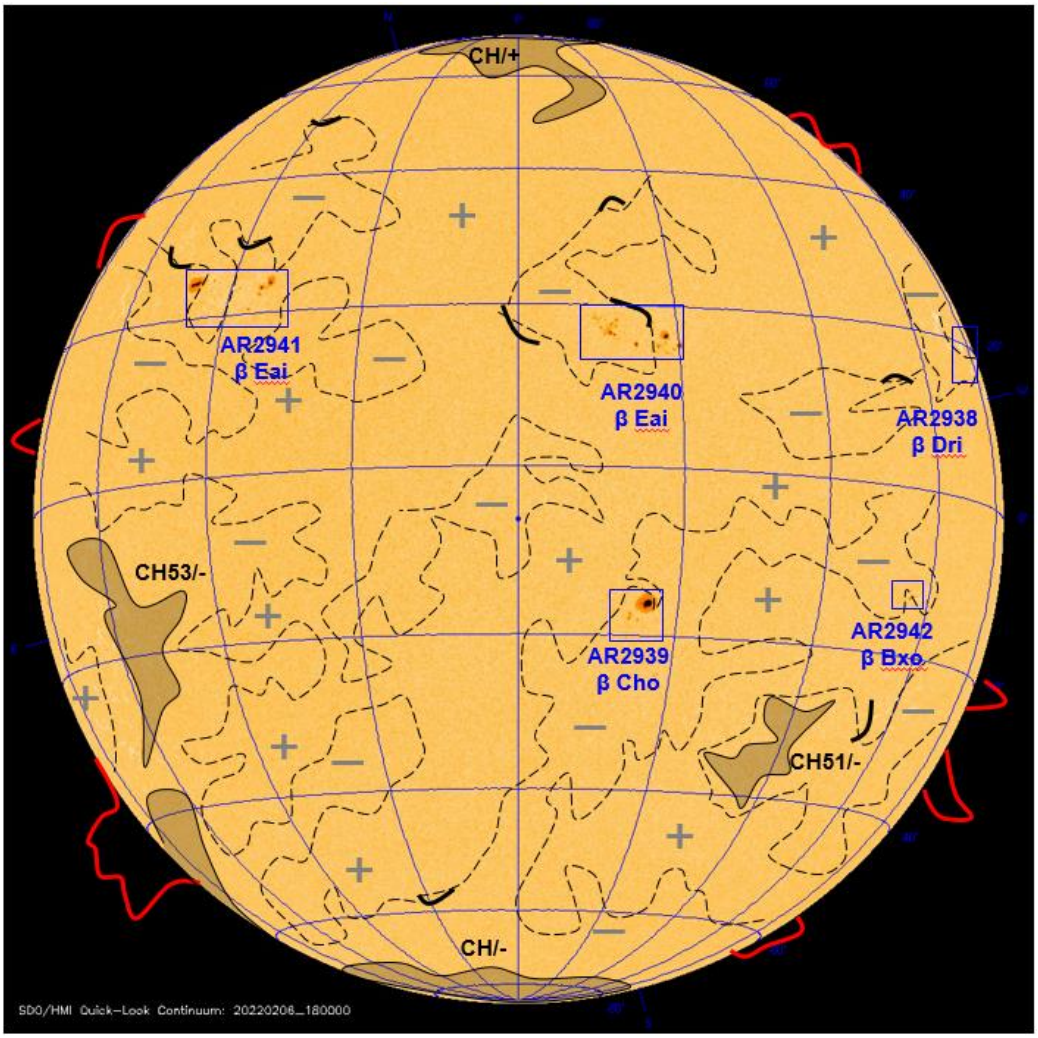
© Crown Copyright 2022. All Rights Reserved.

UTC. There is then the consideration of the possible arrival of the 06 February filament eruption CME, which has been modelled and offers a Likely G1 on day three, Wednesday 09 February, perhaps continuing as a Chance into day four. There is an accompanying Slight Chance of G2, with this not the favoured scenario but most probable near onset should it occur.

Energetic Particles / Solar Radiation: The high energy (greater than 10 MeV) proton flux is forecast to be at background levels, but with a slight chance of rising close to or just above the S1 level given any significant M-class flaring.

High energy electron flux (greater than 2MeV) is expected to continue near current diurnally High flux levels through to midweek. Electron fluence is also expected to remain above the Active (1e8 integrated pfu) threshold in an undamped response to the high speed stream from CH49 and perhaps CH51. This is also likely to continue until the onset of the CME from the 06 February filament eruption, currently thought most likely to arrive on day three, Wednesday 09 February. Should this CME be delayed, there is a Chance of Active fluence surviving as late as day four, however the eventual expected trend in fluence is downwards.

Figure 1. Solar Analysis Valid 06/1800UTC.



Key: Filament ___ , Prominence ___ , Magnetic Field Line - - - , Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α-β-βγ-βγδ and Zurich-McIntosh Axx etc.

Issued by Met Office Space Weather Advisor, Tel: +44 (0) 330 135 4254 Email: moswoc@metoffice.gov.uk

© Crown Copyright 2022. All Rights Reserved.

Geomagnetic Storms:

Earth is currently sampling a relatively stable negative polarity high speed stream - probably that from CH49, but perhaps blending with the succeeding negative coronal hole CH51. These are the only persistent features due in the four-day period, and activity arising from these is likely to have peaked.

The dominant consideration for geomagnetic activity in the period is therefore the potential arrival of the CME from the filament eruption peaking 06/1341UTC from south centre-disc. As discussed in the solar activity section, this emission was very apparent on many EUV image sequences, not least AIA304, where, from an Earth perspective, the ejecta can be seen to rotate clockwise and scatter above, below and onto the ecliptic plane, perhaps mainly orientated very slightly east of Earth's position. MOSWOC Enlil modelling has been conducted using STEREO A CO2 and Lasco C2 imagery, providing a relatively clear correlation. Modelling has resulted in up to three main shock fronts, with two faster emission angled mainly below the Earth, but a third slower emission with a potential Earth-bound component.

MOSWOC Enlil modelling suggests a most likely arrival time of 10:00UTC on Wednesday 09 February, although with error bars factored in, effects are probably best described as becoming apparent during the second half of the remainder of this UTC day, and on into the start of the following day. The deterministic run sits fairly centrally within its ensemble in terms of arrival time and magnitude, with this considered the best forecast given available imagery. This may perhaps to be improved upon with increased Lasco C3 imagery - should this become available.

All considered, G1 intervals from the current waning high speed stream have probably peaked, soon tailing off into the new working week. G1 is then considered Likely for the inbound CME, with perhaps a Slight Chance of G2, partitioned between the final two days of the period, but with a bias towards greater effects nearer onset.

Geo-Magnetic Storm Probability (Exceedance)	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Minor or Moderate	G1 to G2	No	5	1	60	40
Strong	G3	No	1	1	1	1
Severe	G4	No	1	1	1	1
Extreme	G5	No	1	1	1	1

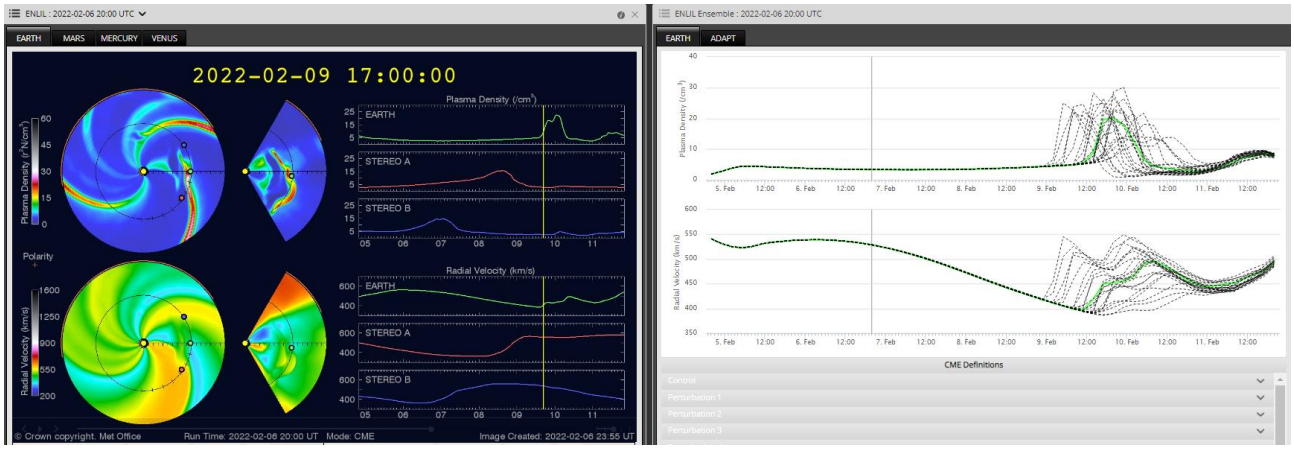
Issued by Met Office Space Weather Advisor, Tel: +44 (0) 330 135 4254 Email: moswoc@metoffice.gov.uk

© Crown Copyright 2022. All Rights Reserved.

Geomagnetic Activity - Earthbound Coronal Mass Ejections

Date/time 21.5R (UTC)	Halo: Full or Partial	Source	Source Location	Estimated Speed	Estimated Arrival Time	Comments
07/02/2022 00:03	Partial	Filament near 2939	Centre-disc	408	09/10:00UTC	Modelled as three separate shock fronts, this is the most obviously Earth-bound but slowest. Reasonable confidence for a partial halo.

Figure 2: MOSWOC Enlil and ensemble, showing arrival time estimates for the 06 February centre-disc filament eruption. Three separate cone files comprise the main shock front, and unpicking the contribution from each is not possible. On balance effects may be skewed later than the detrministic run arrival rather than earlier.



Issued by Met Office Space Weather Advisor, Tel: +44 (0) 330 135 4254 Email: moswoc@metoffice.gov.uk

© Crown Copyright 2022. All Rights Reserved.

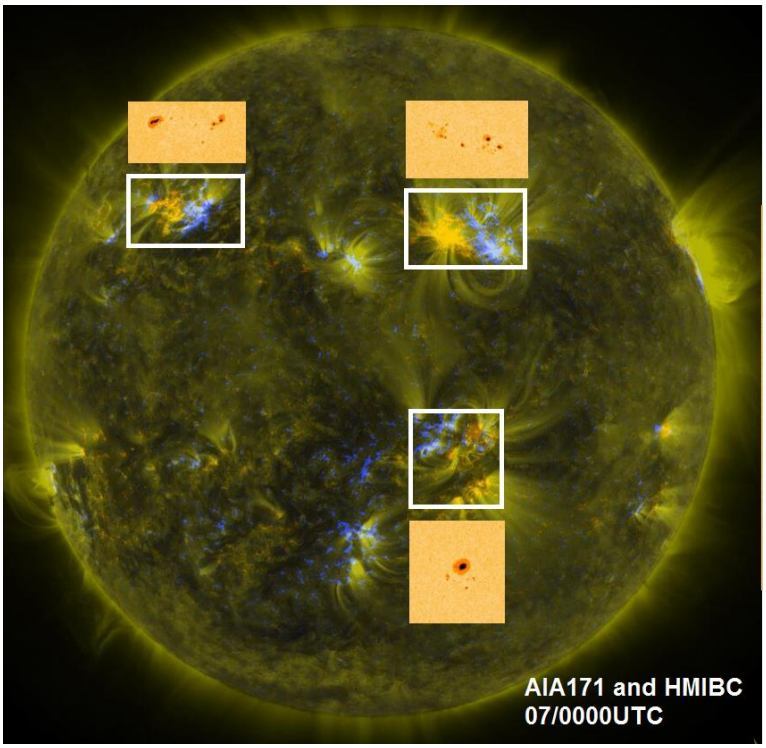
Radio Blackouts - X-Ray Flares:

No significant returning or newly-developed regions appear to lie over the eastern horizon according to STEREO A EUVI195 imagery. Meanwhile, up to two current front-sided regions may leave into the new working week - the larger AR2938 in around 24 hours' time, and AR2942 around midweek UTC. Neither of these groups is contributing significantly to the daily flare risk, meaning that the decline as a result of their passing is very modest.

The remaining daily flare risk is on paper dominated by the two Zurich Eai groups, however these have been relatively inactive, with the largest event of the past 24 hours instead coming from immediately east of the simpler AR2939, a Cho/Beta. Perhaps because of the maturity of the current disc and the slow rates of change observed, activity from the current front-side is tracking below expectations, however a daily Chance of M-class flares is maintained for now, reducing slightly as the number of front-sided groups atrophies.

X Ray Flares	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability			(%)	(%)	(%)	(%)
Active	R1-R2 M Class	No	30	30	25	25
Very Active	R3 to R5 X Class	No	2	2	2	2

Figure 3: Configuration of the three largest sunspot groups on the current Earth-facing disc.



Issued by Met Office Space Weather Advisor, Tel: +44 (0) 330 135 4254 Email: moswoc@metoffice.gov.uk

© Crown Copyright 2022. All Rights Reserved.

Solar Radiation Storms - (High Energy Protons):

The high energy proton flux, as measured by GOES-16 is at background levels. Solar radiation storms are not likely in the period, however there is a very slight chance for proton fluxes to rise given any significant flaring.

Radiation Storms Probability (Exceedance)	Level (cm^{-2} sr^{-1} s^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ S1**	No	2	2	5	5
Very Active	**≥ S3 ***	No	1	1	1	1
* S3 ≥ 10 MeV ≥ 1000 pfu and / or ≥ 50 MeV ≥ 10 pfu. (pfu = $cm^{-2}sr^{-1}s^{-1}$)						

High Energy Electrons Event (≥ 2MeV):

High energy electron flux (greater than 2MeV) is currently exhibiting a stable oscillation peaking at High levels, and is expected to retain this character until around midweek and possible onset of the 06 February filament eruption CME. This feature is likely to significantly redistribute electrons when it arrives, which could be late as day four, hence the survival of a Chance of Active fluence until this time.

There are no further persistent features to re-elevate electron flux counts in the period, although a degree of recovery is possible before the UTC weekend.

GEO Electron Environment Probability (Exceedance)	Level (cm^{-2} sr^{-1} day^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ 2 MeV ≥ $1x10^8$**	No	100	90	80	40
Very Active	**≥ 2 MeV ≥ $1x10^9$**	No	1	5	5	1

Issued by Met Office Space Weather Advisor, Tel: +44 (0) 330 135 4254 Email: moswoc@metoffice.gov.uk

© Crown Copyright 2022. All Rights Reserved.